CLAIMS

1. AUTOMATIC GAIN CONTROL SYSTEM FOR A DIGITAL OFDM MULTIUSER TRANSMISSION SYSTEM OVER THE ELECTRICITY NETWORK, comprising a number of user kits (2) and a head-end kit (1) in two-way communication over the electricity network, with independent control for both an upstream channel which runs from the user kits (2) to the head-end kit (1), and a downstream channel which runs from the head-end (1) to the user kits (2), where a division of the electricity network for both the upstream and the downstream channels is accomplished with frequency division duplexing (FDD) means and/or time division duplexing (TDD) means, where a signal is transmitted with OFDM (orthogonal frequency division multiplexing) modulation means resulting in a signal with non-constant envelope; and comprising amplifiers acting on transmission and reception gains, enabling to use various combinations of head-end (1) and user kits (2), that reuse same frequencies and times, where access to the upstream and downstream channels is accomplished with OFDMA/TDMA (orthogonal frequency division / time division) multiplexing means characterized in that said Automatic Gain Control System comprises:

- carrier by carrier treatment means for emission signals, which attenuate to a greater extent carriers that less attenuated by the channel, and which attenuate to a lesser extent carriers more attenuated by the channel; in order to compensate in advance an effect that a frequency selective channel, as the electricity network, has on the signal before being transformed to a time domain where average power of the signal is fixed,
- carrier by carrier treatment means for received signals in the frequency domain, where a block that compensates an attenuation caused by the channel carries out a scaling in frequency of the received signal and of elements that correct the signal, representing the compensated signal by a floating point and fixing a number of bits of a mantissa to obtain a determined maximum precision, or signal/noise ratio defined by carrier,
- transmission power control means that control the transmission power from various kits (2) with means that increase the power in the carriers that suffer more attenuation on being transmitted by the channel, and decreasing the power in the carriers that are transmitted by the channel with less attenuation; in order to achieve that the power for

various users (2) is received with a same level and to enable to use analog/digital converters of few bits,

- transmission power (S) control means that control the transmission gains in the head-end and user kits; in order to ensure that the signals sent by the users (2) to the head-end (18) do not interfere in a functioning of other groups of head-end (18) and users (2) that may be using the same frequencies and times.

2. AUTOMATIC GAIN CONTROL SYSTEM FOR A DIGITAL OFDM MULTIUSER TRANSMISSION SYSTEM OVER THE ELECTRICITY NETWORK, according to Claim 1, characterized in that the automatic gain control system (10) for the downstream is provided with adjustments means to adjust both gain in the transmitters of the head-end kit (1) as well as gain in the receivers of the user kits (2), in order to introduce maximum average power in the range available for the communication without producing overflows in the system converters for maximizing transmission capacity.

3. AUTOMATIC GAIN CONTROL SYSTEM FOR A DIGITAL OFDM MULTIUSER TRANSMISSION SYSTEM OVER THE ELECTRICITY NETWORK, according to Claim 2, characterized in that the automatic gain control system (10) for the downstream diminishes gain in the receivers of the users (2) in case the number of overflows produced in the ADC receiver surpasses a certain limit, in order to avoid a deterioration in transmission capacity due to overflows which produce a reduction in the S/N ratio.

4. AUTOMATIC GAIN CONTROL SYSTEM FOR A DIGITAL OFDM MULTIUSER TRANSMISSION SYSTEM OVER THE ELECTRICITY NETWORK, according to Claim 2, characterized in that the automatic gain control system (10) in the downstream increases gain in the user receivers (2) in case overflows are not produced in the ADC receiver during a determined time window, in order to prevent the quantification noise (8) from limiting the S/N (6) in comparison with the amplified line noise (N_{Line}+G).

5. AUTOMATIC GAIN CONTROL SYSTEM FOR A DIGITAL OFDM MULTIUSER TRANSMISSION SYSTEM OVER THE ELECTRICITY NETWORK,

according to any of Claims 2 to 4, characterized in that the automatic gain control system (10) for the downstream channel is based on control means that control the number of overflows, saturations in the ADC receiver (7) produced during a certain time window, and equalization weights, in order to reduce the gain in the receiver if the number of overflows in the time window is greater than a certain threshold; in order to increase the gain in the receiver if this threshold is not surpassed for the whole window and the equalization weights indicate that the signal may increase power without producing overflows; and in order to not modify the gain in the corresponding amplifiers, since the system is considered to be at the optimum level if neither of these cases arise; a system to monitor the value of the gain is always used so as to avoid the production of oscillations in the gain and periodic verification that an increase in gain in reception does not improve the signal/noise ratio (6).

6. AUTOMATIC GAIN CONTROL SYSTEM FOR A DIGITAL OFDM MULTIUSER TRANSMISSION SYSTEM OVER THE ELECTRICITY NETWORK, according to Claim 1, characterized in that the automatic gain control system (10) in the upstream channel is provided with adjustment means to adjust both gain in the head-end (1) receivers as well as gain in the user (2) emitters, adjusting the gain in the head-end kit (1) in reception before carrying out the adjustment in gain in the emitters in the user kits (2), in order to avoid deterioration of S/N (6) due to overflows and the quantification noise of the ADC (8) in the head-end kit (1).

7. AUTOMATIC GAIN CONTROL SYSTEM FOR A DIGITAL OFDM MULTIUSER TRANSMISSION SYSTEM OVER THE ELECTRICITY NETWORK, according to Claim 6, characterized in that the automatic gain control system (10) for the upstream channel, fixes the gain in reception of the head-end kit (1) in function of the noise on the line (9), therefore the head-end kit (1) measures the power of the noise (9) and adjusts the gain, in order to prevent the quantification noise of the ADC (8) from limiting the S/N (6) in comparison with amplified line noise (N_{Line}+G) and in order to enable the use a converter with a reduced number of bits.

8. AUTOMATIC GAIN CONTROL SYSTEM FOR A DIGITAL OFDM

MULTIUSER TRANSMISSION SYSTEM OVER THE ELECTRICITY NETWORK, according to Claim 7, characterized in that noise (9) measurement is carried out by the head-end (1) which uses DFT (Discreet Fourier Transform) on the received signal when no user kit (2) is transmitting, it being able to estimate line noise (9) by increasing gain in reception and comparing the exit of said DFT with a certain threshold when no user kit (2) is transmitting.

9. AUTOMATIC GAIN CONTROL SYSTEM FOR A DIGITAL OFDM MULTIUSER TRANSMISSION SYSTEM OVER THE ELECTRICITY NETWORK, according to Claim 7, characterized in that said noise (9) measurement is accomplished starting from the error signal supplied by the reception equalizer in the head-end (1) and from the known gains of the transmission and reception amplifiers, while some users (2) are transmitting.

10. AUTOMATIC GAIN CONTROL SYSTEM FOR A DIGITAL OFDM MULTIUSER TRANSMISSION SYSTEM OVER THE ELECTRICITY NETWORK, according to Claim 6, characterized in that for the upstream channel, the gain control system controls the emission amplifiers in the user kits (2) in open loop and/or in closed loop in order to maximize transmission capacity and reduce the number of bits necessary for the conversion in the ADC over the whole signal range, wherein:

- in open loop control, the quantity of power that should be transmitted by the upstream channel is estimated by means of the power received in the down stream channel; and
- in closed loop control, the head-end kit (1) receives the signal from the user kit (2) and measures its power in reception, as well as if it produces overflows in the corresponding ADC; and starting from this measurement indicates to the user kit (2) if it should increase or decrease the emission gain amplifier, preferably by sending control messages.

11. AUTOMATIC GAIN CONTROL SYSTEM FOR A DIGITAL OFDM MULTIUSER TRANSMISSION SYSTEM OVER THE ELECTRICITY NETWORK, according to any of Claims 7 to 10, characterized in that the gain control system works with

an algorithm in the upstream channel that comprises:

- evaluating firstly, the number of overflows in the time window and lowering the gain if the number of overflows in the time window is greater than a maximum permitted threshold;
- to determining which gain should be reduced, emission by the user kits (2) or the reception in the head-end kit (1) use, the information given by the weight equalizers in order to distinguish if the overflows have been produced due to the information signal sent by the user, in whose case the head-end kit (1) indicates to the user kit (2) to lower the emission level, or if they are due to line noise (9), in whose case it will be the head-end kit (1) that will reduce gain in reception;
- gain increase, which is only used when no reasons exist to diminish gain, so that this gain increase occurs in the user kits (2) only when it will not lead to overflows;
- a system to monitoring the value of the gain to avoid oscillations is always used;
- at certain times, that are sufficiently spaced apart, the communication line is monitored to check that the fixed value for gain in reception was correct, impulse noise on the network may provoke an inadequate adjustment, and if necessary this value is modified.

12. AUTOMATIC GAIN CONTROL SYSTEM FOR A DIGITAL OFDM MULTIUSER TRANSMISSION SYSTEM OVER THE ELECTRICITY NETWORK, according to Claim 1, characterized in that to optimise gain control a carrier by carrier treatment of the corresponding emission signals is used to compensate in advance for the effect of the channel on the signal, by means of increasing the power in the carriers that suffer more attenuation on being transmitted by the channel and decreasing the power in the carriers that are transmitted in the channel with less attenuation, so that average transmission power is maintained and transmission capacity can be increased without producing overflows in the treatment of the signal in time (4) or in the analog/digital conversion.

13. AUTOMATIC GAIN CONTROL SYSTEM FOR A DIGITAL OFDM

MULTIUSER TRANSMISSION SYSTEM OVER THE ELECTRICITY NETWORK, according to Claim 12, characterized in that among the carrier by carrier treatments in transmission there is a gradual attenuation that includes elimination of carriers whose frequency position coincides with frequencies whose use is regulated by Law, with frequencies that interfere with other communication devices, with intermediate frequencies used in television and other electronic devices, with radio amateur frequencies, and the like, and where the selection of carriers is configurable in real time according to the communication necessities of the system at each moment.

14. AUTOMATIC GAIN CONTROL SYSTEM FOR A DIGITAL OFDM MULTIUSER TRANSMISSION SYSTEM OVER THE ELECTRICITY NETWORK, according to Claim 1, characterized in that in order to optimise gain control, carrier by carrier treatment of the corresponding signal in reception is carried out, once in the frequency domain, consisting in that the block that compensates the effect of the channel on the received signal scales both the received signal in each carrier according to the level estimated for the same as well as the values of the frequency corrector elements used on the signal, so that it enables to work only with the reception mantissa in floating point, mantissa and exponent, of the received signal and finally the number of bits of this mantissa is fixed according to the maximum precision, or signal/noise ratio, of the carrier; in order to represent the signal with a large dynamic range, that is signals with very high or very low power, by means of a very few number of bits, reducing the size of the memories used to store the operations in the frequency domain to have a reduced number of bits in same and amplify to the maximum the signal at the entrance to the analog/digital conversion without producing overflows in the blocks previous to the treatment of the signal in the frequency domain carrier by carrier, receiving the carrier with greater attenuation is limited in signal/noise ratio in reception by the noise on the line and not by the quantification noise of the A/D converter, and at the same time, receiving the carrier that are less attenuated by the line and amplified before the conversion without producing overflows on being conveniently scaled so that they can be treated by the frequency blocks with the same number of bits in each operation as for the carriers with greater attenuation.

15. AUTOMATIC GAIN CONTROL SYSTEM FOR A DIGITAL OFDM MULTIUSER TRANSMISSION SYSTEM OVER THE ELECTRICITY NETWORK, according to Claim 14, characterized in that in the scaling process, the signal mantissa is obtained on multiplying the signal received by the exponent of the floating point representation of the equalization weights, and where this exponent updates itself in the equalization training phase in the grid carriers if the data send is directed to another uses and in all carriers when the data sent is directed to our user, so that the probability of an scale error due to the multiple impulsive noises that affect communication over the electricity network is reduced.

16. AUTOMATIC GAIN CONTROL SYSTEM FOR A DIGITAL OFDM MULTIUSER TRANSMISSION SYSTEM OVER THE ELECTRICITY NETWORK according to Claim 1, characterized in that the coexistence of various groups of head-end (18) and users (2) in communication with the former, using the same frequencies and times reusing frequency and time is achieved by means of controlling transmission gains in these kits, while the means of controlling reception has been described in the previous Claims, so that the various head-end kits (18) communicate between themselves to take co-existence decisions.

17. AUTOMATIC GAIN CONTROL SYSTEM FOR A DIGITAL OFDM MULTIUSER TRANSMISSION SYSTEM OVER THE ELECTRICITY NETWORK, according to Claim 1, characterized in that the coexistence of various groups of head-end (18) and users (2) in communication with the former, using the same frequencies and times reusing frequency and time is achieved by means of controlling transmission gains in these kits, while the means of controlling reception gains is achieved by the means as described in the previous Claims, so that a principal head-end kit (1) exists that uses different frequencies and/or times for communication with its users (2), and is responsible for ensuring coexistence between the various groups of kits (18,2) that reuse the same frequencies and times and it is capable of communication with the head-end of each group (18).

18. AUTOMATIC GAIN CONTROL SYSTEM FOR A DIGITAL OFDM MULTIUSER TRANSMISSION SYSTEM OVER THE ELECTRICITY NETWORK, according to either of Claim 16 and 17, characterized in that to optimise the gain control result when there are various groups of head-end (18) and users (2) reusing the same frequencies and times, transmission gains are modified carrier by carrier, or the average signal/nose ratio in frequency is estimated considering carriers with greater signal/noise ratio than those with less; using this result to achieve the modifications in transmission gains.

19. AUTOMATIC GAIN CONTROL SYSTEM FOR A DIGITAL OFDM MULTIUSER TRANSMISSION SYSTEM OVER THE ELECTRICITY NETWORK, according to any of Claims 16 to 18, characterized in that the coexistence of various groups of head-end (18) and user kits (2) using the same range of frequencies and time for the communications, is carried out by means of:

- power control in the corresponding signal emission means in both communication channels, downstream and upstream;
- a network topology where the signals from all the user kits (2) first pass by the head-end kit corresponding to their group before arriving to the kits (18,2) that make up another group; and
- measuring attenuation between the head-end kits (18), that reuse the same frequencies and times, by sending information between these head-end kits (18), or by means of communication with a principal head-end kit (1), so that this measure is used to adjust the maximum transmission power possible for the user kits (2).

20. AUTOMATIC GAIN CONTROL SYSTEM FOR A DIGITAL OFDM MULTIUSER TRANSMISSION SYSTEM OVER THE ELECTRICITY NETWORK, according to any of Claims 16 to 18 characterized in that in the downstream channel all the head-end kits (18) emit at the maximum power possible for communication over the electricity network (S_1,S_2), so that the maximum value for the signal/noise (S/N) ratio (6) in the user receptors will be limited by the attenuation between the head-end kits (L) that reuse the same range of frequencies and times, while if there is a principal head-end (1), that uses

another range of frequencies and /or times, it will be this principal head-end kit (1) that will be responsible for adjusting the different gains required in the various head-end kits (18) by means of channel control and preferably by means of control messages.

21. AUTOMATIC GAIN CONTROL SYSTEM FOR A DIGITAL OFDM MULTIUSER TRANSMISSION SYSTEM OVER THE ELECTRICITY NETWORK, according to any of Claims 16 to 18, characterized in that to guarantee the coexistence of various groups of kits (2) that reuse the same frequencies and times in the upstream communication channel, transmission gain in the user kits (2) is adjusted so that the level of signal power that reaches the head-end (18) of another group, and that would be an interference for this group, is comparable to the level of noise on the line (9).

22. AUTOMATIC GAIN CONTROL SYSTEM FOR A DIGITAL OFDM MULTIUSER TRANSMISSION SYSTEM OVER THE ELECTRICITY NETWORK, according to Claim 21, characterized in that in the upstream communication channel, the head-end kits (18) detect the power that arrives from one of its users and decides if the gain should be increased or decreased, later communicating this information to the user kit (2) involved preferable by means of control messages; the head-end (18) taking the corresponding decision by means of using the estimated value of the signal/noise ratio considered in frequency, prior values of said estimate and an estimation of noise.